

Perspectives on Driver Preferences for Dynamic Route Guidance Systems

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Insights about the design of route guidance systems based on the needs and desires of drivers who are familiar with the travel network are provided. Results from the ADVANCE Intelligent Transportation System operational test, in which more than 100 drivers used vehicles equipped with dynamic route guidance systems for 2-week periods, suggest that such drivers value real-time traffic information, and they want to incorporate their own knowledge and perspectives into the development of route plans, which they expect to be superior to those prepared by the navigation computer. This suggests that future route guidance systems likely to be targeted at familiar drivers should be based on a sharing of tasks between computer and driver that takes greater advantage of driver knowledge than that considered in current designs. Specifically, the driver should be able to take more responsibility for route planning, with the computer responsible mainly for traffic congestion data acquisition, organization and storage, and evaluation of driver-defined routes.

The purpose of dynamic route guidance systems (DRGSs), a class of advanced traveler information systems (ATISs), is to provide drivers with routing instructions based on real-time traffic information. By helping drivers to avoid congestion, especially nonrecurring (incident-based) congestion, such systems should provide better (faster, more direct) routes than drivers could otherwise plan for themselves. Such systems must provide drivers with valuable information in a manner that supports their decision making if dynamic route guidance is to succeed in the marketplace. Further, such systems may provide broader social benefits by facilitating more efficient use of the road network by both users and nonusers (1,2).

A fundamental question in the design of a DRGS addresses its role in the route planning task. Most developers of in-vehicle route planners have provided drivers with full origin-to-destination route plans based on real-time traffic information and predetermined route-choice criteria (3). The driver's task is to follow those routes.

However, drivers who make repeated trips over the same network, and to the same destinations, presumably accumulate a great deal of network knowledge, including both structure and temporal performance variations, and have well-developed preferences for certain routes. These "familiar drivers" are persons traveling around their home communities for routine commuting and other trips. Their route guidance needs are arguably different from those of visitors, who may be more concerned with direction finding than time savings (4).

In this paper the authors use some of the results of the ADVANCE Intelligent Transportation System (ITS) field operational test to explore the route guidance needs of familiar drivers. ADVANCE is described briefly, along with the field evaluation procedures used. Some findings, qualitative and quantitative, from ADVANCE are

presented and interpreted in terms of their contributions to the design of future DRG systems.

BACKGROUND AND APPROACH

ADVANCE (Advanced Driver and Vehicle Advisory and Navigation Concept) is an ITS partnership involving FHWA; the Illinois Department of Transportation; Motorola, Inc.; the American Automobile Association; and the Illinois Universities Transportation Research Consortium (Northwestern University and the University of Illinois at Chicago) (5). ADVANCE developed, implemented, and tested an in-vehicle route guidance system designed to give drivers navigation and real-time traffic congestion information. The setting was northwest suburban Chicago, where most of the travel is on the heavily congested arterial street system, a network so large and complex that relying on broadcast radio traffic information, which works well for sparse expressway networks, is infeasible. The target market for ADVANCE was familiar drivers, people traveling in their own communities, who are experienced with network structure and congestion patterns.

ADVANCE vehicles were equipped with navigation computers using differential global positioning system (GPS) satellites, dead reckoning, and map matching; radio transceivers to receive real-time traffic information from a central computer and to automatically send link travel time reports to that computer; a CD-ROM-based network representation including typical (historical) link travel times; and a color liquid crystal display (LCD) showing the network map and vehicle position or route guidance arrows and text, with a touch screen for specifying destinations (5).

The ADVANCE familiar driver test (6) was designed to measure the perceptions and behavioral reactions of such drivers to the DRGS. The original plan was to equip 3,000 to 5,000 privately owned vehicles with ADVANCE systems, and to allow the owners of those vehicles to use the system for 12 to 18 months. ADVANCE is a probe vehicle-based concept, with each participating vehicle operating as an autonomous travel time probe, and the large deployed fleet was designed to generate a large quantity of real-time traffic data to support dynamic route guidance.

For a variety of development and scheduling reasons, a much-reduced targeted deployment scheme was ultimately adopted; it focused both the scale and time period of field testing, so that only 80 households were able to drive project-owned ADVANCE vehicles and the driving period was shortened to 2 weeks. Thus, the scope of this evaluation was limited by two factors:

1. Because of the small fleet, few probe vehicles were in operation at any time and thus there was relatively little real-time traffic

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data available to support DRGS. Drivers could experience the operations and feel of ADVANCE, but they could not test its full dynamic route guidance capability.

2. The 2-week driving period gave drivers a limited time to use the system in their daily travel.

The reduced objective of this test, then, was to allow a small sample of drivers familiar with their local road network to test and evaluate the ADVANCE system and, on the basis of their experience, to provide a forward-looking evaluation of the features of future in-vehicle navigation systems.

Up to two drivers from each of 80 volunteer households were selected to use ADVANCE-equipped vehicles for 2 weeks each. Households were chosen from more than 400 adult drivers who volunteered to participate. These volunteers learned about ADVANCE through news stories and word of mouth. Drivers and their households were screened for eligibility based on the following criteria applied to the self-selected primary driver and one alternate driver:

1. Residence in the 300-mi² ADVANCE test area;
2. Twenty-five years of age or older;
3. Good driving record, verified by checking the files of the Illinois Secretary of State; and
4. No reported perceptual or health problems that would threaten driving ability.

Among those households eligible to participate, households were selected for the experiment based on measures of trip-making intensity (more active travelers were preferred) and schedule availability. Participating drivers were briefed on test requirements and trained to use the ADVANCE unit in 2-hr hands-on sessions. They were free to, and encouraged to, use the test vehicles for their normal driving trips within the study area during the 2-week test.

Participants completed a baseline survey measuring demographic characteristics, driving habits, attitudes, and experience with the road network and electronic technologies before beginning their use of the test vehicle. At the end of the driving period, drivers completed a post-test survey covering experiences with and reactions to ADVANCE and preferences for features of future route guidance systems. Thirty-two of the 110 persons who actually drove the vehicles also participated in focus groups exploring their perspectives on future route guidance systems.

This sample is clearly biased. All drivers were volunteers, not from a random sample of the population, but persons who wished to be involved in this experiment. For at least one driver in each household, the desire to test this navigation technology was high enough that he or she sought out this opportunity. Volunteer bias is characteristic of experiments of this type; it is not possible to select drivers randomly, and those who volunteer are likely to be different than the rest of the population. They might best be described as “early adopters,” people who are especially interested in new technologies; they may be more favorable to such innovations, or more critical in their evaluations.

However, informal discussions with drivers suggested that at least some of them had no more than a modest interest in the ADVANCE technology. These were the spouses of the primary driver who sought the opportunity to participate in the test. They participated in the experiment as cooperative spouses rather than as technology buffs or early adopters. Their presence in the sample may have moderated the self-selection bias.

DRIVER PROFILE

Eighty households participated in the test, and 77 returned the post-test survey, representing 110 drivers (77 primary and 33 alternate drivers). Sixty-two percent of all drivers, and 70 percent of the primary drivers, were men. Mean age was 44 years (range: 26 to 69 years). Sixty-nine percent of the drivers had bachelor's degrees or a higher level of education. Thirty-nine percent reported household incomes between \$75,000 and \$100,000; 95 percent of the incomes were over \$50,000 per year.

Ninety-five percent of the households had two or more motor vehicles available. Eighty-five percent of the participants were employed full-time (94 percent of men, 75 percent of women). Sixty-six percent described their occupations as managerial, professional, or technical (70 percent of men, 60 percent of women). Eighty-five percent of the drivers worked outside of the home at least 5 days a week, and all of these drove to work 5 or more days a week. Respondents reported driving an average of 16,000 mi/year (32 percent drove more than 17,500 mi, 3 percent more than 32,500 mi).

Drivers reported using the ADVANCE vehicles for an average of 3.83 round trips per day (standard deviation 4.83); they indicated that the number, length, and destinations of these trips did not change substantially from their behavior patterns of before the test.

FINDINGS

Focus Group Results

Focus groups are structured discussions for the qualitative exploration of attitudes and perceptions. The results are not intended for quantitative analyses but are useful for exploring the ways in which people perceive products, services, and concepts. The authors conducted three focus groups with a total of 32 ADVANCE drivers shortly after the completion of their driving experience. The major issues discussed during the focus group meetings included evaluation of their experience with ADVANCE, their interests in features of future route guidance systems, their ideas about how they would prefer to use a future DRGS, their willingness to pay for future systems, and their thoughts about the kinds of drivers likely to be interested in such systems and the types of trips that would obtain greatest benefit from such systems.

On the basis of the gender-vehicle usage patterns observed in the training sessions and post-test surveys, one focus group was conducted with only female participants, one with only male participants, and one mixed male-female group. This was done to reduce within-household gender influences so that a better notion of the perceptions and preferences of women and men would be developed.

Focus groups were moderated by the senior author and observed by the other authors and other members of the ADVANCE team. Both video and audio recordings were made, providing ample opportunity for verification of the findings, selections from which are presented in the following sections.

Real-Time Information

Real-time information was more appealing to drivers than route planning based on static information (e.g., maps). Participants thought that they could plan their own routes well, better than the computer system, using their knowledge of the network and its congestion patterns. Although they saw value in information about (static) network

structure (e.g., an electronic map and a static route planner) for occasional new trips or visitors, there was a stronger preference for real-time traffic information, even without route guidance; that is, just traffic information, perhaps on a schematic map. Some were interested in customized traffic reports for their routes or communities.

Drivers were particularly interested in timely traffic information to provide a basis for making their own route plans, detailed information that would support their own route choices (What is happening on the network? What is the cause of the congestion? Where is it located?). Participants were aware that they need and do not have real-time data for arterial streets, though such information is generally available for expressways. Some expressed willingness to buy real-time information on a per-trip or per-month basis.

Route Planning

Most focus group participants believed that the quality of ADVANCE route plans was not good enough. Some routes were longer, sometimes much longer, in time and distance than users' own routes. Many were frustrated because the DRGS did not give them what they thought were the best routes. Some of this was probably due to data base errors, either in the network map or the historical travel times; but some inferior routes were caused by the structure of the route planner and its path selection criteria, which were designed to assign drivers to higher-level roadways, thereby reducing use of local (residential) streets. Such routes were often not the most direct and logical, and familiar drivers quickly recognized this, often reverting to their own preferred routes.

These route planning limitations are not unique to ADVANCE. The preference for routing drivers on major streets is consistent with public policy to avoid routing traffic on more sensitive residential streets. This bias is likely to be built into any publicly sponsored or sanctioned route planner, although alternative implementations of this policy might be accomplished that would be less limiting to the drivers and, therefore, result in greater acceptance and use of the recommended routes. The focus groups revealed the obvious: familiar drivers know shortcuts and faster routes that rely on streets that are lower in the functional classification hierarchy. They also know network quirks that may provide faster trips but may not be coded into network data bases. Drivers who know these streets and tricks, and most drivers are likely to learn them through experience, are not likely to be satisfied with computer-provided routes based on a socially acceptable routing algorithm.

Participants were clearly interested in more driver control over route planning. Self-routing was especially preferred in cases in which real-time information was poor or lacking. In the future, if congestion information becomes better, drivers said they would develop more confidence in the quality of routes provided by the system and would be more likely to use the route guidance.

One manifestation of the desire for more control over route planning was the preference of many drivers to set their own route planning criteria; they suggested criteria such as minimizing time or distance, keeping moving, avoiding a particular street or street type (e.g., tollways, expressways), using certain streets, and avoiding traffic lights, left turns, grade crossings, and so on.

Some participants were interested in routing options, not merely a single recommended route, to give drivers control over route choice. Such options could be provided by displaying alternative routes on a map, which was generally preferred to the text or link-by-link arrow displays used in ADVANCE to preview entire routes.

For those who are comfortable with maps, this would provide an easy way to give users greater control over the choice of routes.

Participants in all three focus groups suggested that more driver control over routes could be implemented through a route planner that can learn drivers' favorite routes and local shortcuts, perhaps by monitoring driver routes and deviations from computer-recommended routes. The on-board system could use real-time data to evaluate drivers' own routes in terms of travel time and current congestion, proposing alternatives when those might be faster. If the DRGS primarily followed user-defined routes, individual needs and preferences may reduce the likelihood that neighborhood streets will experience major traffic increases.

Focus group participants suggested that the process of teaching a personal route to the computer system might be like "writing a macro . . . like telling the computer to 'learn this script (route)'. . . ." Some proposed that they could demonstrate the route by driving it with the computer in a learning mode.

Survey Results

Performance and Importance of ADVANCE Features

Focus group results concerning route planning are confirmed in Figure 1, which shows mean driver ratings of the importance and performance of 13 ADVANCE features shown in order of stated importance; these features are described in Table 1. Importance responses were on a nominal scale from 1 (not at all important) to 5 (very important); performance responses were on a scale from 1 (very poor) to 5 (very good). Most features were rated as important, with most scores above 4.0. Among the most important features were accuracy of destination finding, route quality, system reliability, and overall route planning performance. Of these, route planning performance and route quality were rated relatively poorly. This suggests an important gap between expectations (interpreted here as importance) and results produced by the ADVANCE system (represented here as performance). Some aspects of the user interface were also poorly rated: destination entry, tedious with the small touchscreen; and startup speed and route planning time, constrained by limited computing capacity in the experimental units. These deficiencies had been recognized before the field tests and should be easy to overcome in future systems.

Comparative Route Quality

The post-test survey asked respondents to compare ADVANCE-provided routes with their own on five dimensions. The mean scores on a scale from 1 (strongly disagree) to 5 (strongly agree) are given in Table 2. Compared with other ratings of ADVANCE features, these scores are low. ADVANCE routes compared particularly unfavorably on short travel times and distances. This again supports the focus group results, where participants claimed to know, and use, better, quicker, and more direct routes than the ADVANCE route planner gave them.

INTERPRETATION AND IMPLICATIONS FOR DRGS DESIGN

The findings suggest that drivers who are experienced with their local road networks have specialized route guidance needs, reflecting their

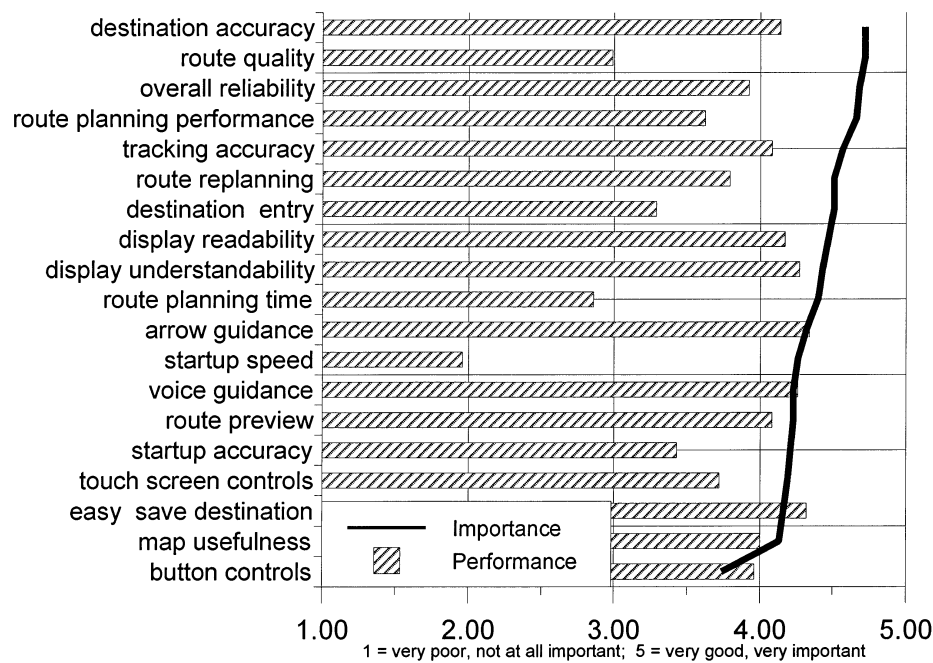


FIGURE 1 Mean importance and performance ratings of *ADVANCE* features.

preexisting network knowledge. Participants in the *ADVANCE* experiment believed that they could do a better job of route finding than the route planning algorithm. Anecdotal evidence suggests that this is due to such factors as (a) routing biases built into the algorithm as a matter of policy, (b) coding errors and procedures that may

not have taken advantage of local network details, and (c) limits in the quality of the travel time data base compared with the evolving experience of regular travelers.

While the computer data base describing both network structure and historical travel times can be expected to be improved over time,

TABLE 1 Description of Rated *ADVANCE* Features

Label in Figure 1	Description
destination accuracy	ability of DRG to navigate to correct destination
route quality	user-defined relative route quality
overall reliability	overall performance reliability of <i>ADVANCE</i> system
route planning performance	performance of entire route planning process, including results
tracking accuracy	accuracy of tracking actual vehicle route
route replanning	performance of en-route replanning capability
destination entry	ease of keying in destination
readability	ease of reading color LCD display
understandability	ease of display interpretation
route planning time	time required to plan routes
arrow guidance	route guidance through directional arrows and text only
startup speed	time from vehicle start to full DRG functionality
voice guidance	route guidance voice instructions
route preview	preview of planned route
startup accuracy	accuracy of vehicle position at startup
touch screen controls	controls accessed via touch screen
easy save destination	ease of saving driver-entered destinations for future use
map usefulness	usefulness of map display of vehicle position
button controls	controls accessed via hard buttons on display head

TABLE 2 ADVANCE Route Quality Compared with Drivers' Own Routes

Compared with driver's routes, <i>ADVANCE</i> routes were...	Means responses
direct	3.25
fast, with shortest travel times	2.94
short, no excess distance	2.74
simple, no complex maneuvers	3.54
logical, sensible	3.14

as it was designed to do in *ADVANCE*, routing policies and unique local knowledge, as well as personal preferences, are likely to remain sources of differences between driver-planned routes and those developed by computer algorithm.

These findings about route planning suggest that, for familiar drivers, an important market for the commercial success of in-vehicle route guidance systems, there may be a need for a radically different approach to route guidance than the contemporary implementations in *ADVANCE* and other on-board route planning systems. This concept would use the computer as intelligent assistant to the driver-expert. Both driver and computer bring unique information and capabilities to the route planning task. Familiar drivers know their routing criteria, which may vary across trips and perhaps even within a single trip. They know the network and its congestion patterns. They are inherently self-serving (individual utility maximizing), and thus (for better or worse) unfettered by public policies about route selection. Computers can process information rapidly, receive and analyze large quantities of information about current network conditions, and quickly compare proposed routes against real-time conditions using criteria selected by the driver. Where appropriate, they can plan alternative routes.

These results also suggest that drivers will probably be able to detect, and will most likely resist, system optimal routes. Producing an overall social benefit may be the objective of network managers, but it does not always reflect the preference of individual drivers. Indeed, in focus groups conducted to guide the *ADVANCE* driver recruitment process, long before the in-vehicle system was developed, some participants anticipated the concept of system optimal routes and specifically indicated that they would not want a DRGS based on this objective (7).

From these results, Table 3 suggests a division of the typical tasks involved in route planning between driver and computer. For comparison, the authors speculate on the task allocation for route planning in the case of unfamiliar drivers, visitors for work or leisure purposes who do not have good local network knowledge.

Though it is possible to store much more, and more detailed, network structure knowledge in the computer, familiar drivers may have better knowledge of the intricacies that will provide them with better route plans. This probably will *not* be the case for visiting drivers, who have been shown to be well-supported by computer maps and route guidance (2). The same might be argued for knowledge of recurring congestion, or historical travel times. Commuters, in particular, are likely to have a strong sense of the regular patterns of congestion.

Knowledge of nonrecurring, or incident-based, congestion must come from an external source. Radio traffic reports can fill this need on sparse limited-access networks, but the volume of data necessary to describe congestion on a broader network, including major arterials, is too large to be conveyed orally and cannot be screened by the driver. Key computer functions under this task are to acquire real-time traffic condition data (through high-speed computer-to-computer communications), sort through all of the data to find that which is relevant, and make that information available to the driver.

Route planning criteria obviously come from the driver; they are likely to be more complex than simple minimization of time or distance. Drivers have individualized preferences for link and route attributes and may trade these against each other in different ways at different times. This implies, at least for drivers who have good network knowledge, that even the route planning task might be left to the (familiar) driver under normal conditions. Stated differently, findings from these focus groups suggest that such drivers will do their own route planning anyway. The focus groups also suggest the desirability of developing a system that will allow the on-board computer to "learn" user criteria for route selection.

Because drivers differ in their needs, preferences, and abilities, self-directed route planning may decrease the likelihood that a large fraction of the traffic is diverted to a single facility, thus causing increased congestion on that facility.

Such a route planning model would be a learning, artificial intelligence system, based on a partnership between driver and computer, rather than a static software package that merely presents directives to the driver. Such a route guidance system would probably be more complex to develop, but it would provide drivers with more preferred routes and a more desirable degree of individual control and customization. Such a product, then, would be more likely to improve drivers' travel experience and thus would be more likely to be purchased and used.

ACKNOWLEDGMENTS

This work was funded and developed for the *ADVANCE* Project, a joint ITS undertaking by FHWA, the Illinois Department of Transportation, the University of Illinois at Chicago and Northwestern

TABLE 3 Proposed Route Planning Task Allocation

Route Planning Task	Familiar Driver	Visiting Driver
Network structure knowledge	Driver	Computer
Recurring congestion knowledge	Driver	Computer
Non-recurring congestion knowledge acquisition and organization	Computer	Computer
Route planning criteria	Driver	Driver
Route planning process	Driver	Computer

University operating under the auspices of the Illinois Universities Transportation Research Consortium, Motorola, and the American Automobile Association.

REFERENCES

1. Commeignes, H., *User Perceived Benefits with Navigation Systems*. Program on Advanced Technology for the Highway, Institute of Transportation Studies, University of California, Berkeley, 1991, pp. 2–7.
2. Hicks, J. E. *Static Network Equilibrium Models and Analyses for the Design of Dynamic Route Guidance Systems*. Ph.D. thesis. University of Illinois at Chicago, 1992.
3. Catling, I. (ed.). *Advanced Technology for Road Transport—IVHS and ATT*. Artech House, London, 1994.
4. *TravTek Evaluation—Rental and Local User Study*. Publication FHWA-RD-96-028. FHWA, U.S. Department of Transportation, March 1996.
5. Boyce, D. E., A. M. Kirson, and J. L. Schofer. *ADVANCE—The Illinois Dynamic Navigation and Route Guidance Demonstration Program*. In *Advanced Technology for Road Transport—IVHS and ATT* (I. Catling, ed.) London, 1994, pp. 247–270.
6. Schofer, J. L., F. S. Koppelman, and W. A. Charlton. *Familiar Driver Perspectives on ADVANCE and Future Dynamic Route Guidance Systems*. ADVANCE Project Document 8462. ADV.01; <http://ais.its-program.anl.gov/reports/alpha.listing.html>. July 1996.
7. Schnaiberg, A., and J. L. Schofer. *Driver Recruitment Focus Groups*. <http://ais.its-program.anl.gov/reports/alpha.listing.html>. ADVANCE Project, Nov. 1991.

The contents reflect the views of the authors, who are responsible for the information and accuracy of the data presented; they do not constitute a standard, specification, or regulation, nor do they necessarily reflect the official policy of any of the ADVANCE parties.

Publication of this paper sponsored by Committee on Intelligent Transportation Systems.